Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 17, 2020

Special blog on winter 2018/2019 retrospective can be found here - http://www.aer.com/winter2019

Special blog on winter 2017/2018 retrospective can be found here - http://www.aer.com/winter2018

Special blog on winter 2016/2017 retrospective can be found here - http://www.aer.com/winter2017

Special blog on winter 2015/2016 retrospective can be found here - http://www.aer.com/winter2016

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) recently embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation (AO) and Polar Vortex (PV). This analysis is intended to provide researchers and practitioners real-time insights on one of North America's and Europe's leading drivers for extreme and persistent temperature patterns.

During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather. With the start of spring we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to remain neutral to negative over the next two weeks.
- The current negative AO is reflective of mostly positive pressure/geopotential height anomalies across the Arctic with mixed pressure/geopotential height

anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently neutral with weak pressure/geopotential height anomalies spread across Greenland; and the NAO is predicted to be negative to neutral the next two weeks as pressure/geopotential height anomalies turn mostly positive the next two weeks across Greenland.

- This week Europe including the United Kingdom (UK) will be dominated by ridging/positive geopotential height anomalies with normal to above normal temperatures. However next week, troughing/negative geopotential height anomalies with normal to below normal temperatures are predicted for Western Europe including the UK with ridging/positive geopotential height anomalies with normal to above normal temperatures for Eastern Europe.
- The predicted pattern for Asia this week is troughing/negative geopotential height anomalies with normal to below normal temperatures in Western and Northeastern Asia with ridging/positive geopotential height anomalies with normal to above normal temperatures across Southeastern and Central Asia. However, starting next week ridging/positive geopotential height anomalies will strengthen with normal to above normal temperatures across Western and Northern Asia forcing troughing/negative geopotential height anomalies with normal to below normal temperatures in Central Asia with more ridging/positive geopotential height anomalies and above normal temperatures in Far East Asia.
- The general pattern for North America the next two weeks, is ridging/positive geopotential height anomalies with normal to above normal temperatures for western North America including Alaska with troughing/negative geopotential height anomalies accompanied by normal to below normal temperatures in eastern Canada and the Eastern United States (US).
- In the Impacts section I discuss the feeling that summer is winding down across much of the Northern Hemisphere (NH).
- We have updated the surface temperature forecast plots and hopefully resolved the long existing biases in the plots.

Impacts

We certainly have seen some impressive heat this summer from the Siberian heat wave in June, Eastern Canada (that likely contributed to the collapse of an ice shelf on Elsmere Island) and the Northeastern US, the Mediterranean and the Middle East in July, Northwestern Europe in early August and now western North America in mid to late August. Yesterday, aptly named Furnace Creek in Death Valley, California recorded 130°F (54.4°C) which would be the hottest observed global temperature in August and one of the three hottest temperatures ever recorded for any month. The record heat wave is causing power shortages in California and wildfires this weekend spawned tornadic pyrocumulus, a phenomenon that I was unaware of until this weekend.

Though summer heat is at its peak across the Western US and persists across Northern Europe for a few more days it does feel like the back of summer has been broken across the Eastern US and will shortly across Western and Northern Europe. And though I fully expect a warm month of September it is hard to see a return of the extreme heat of July and into early August.

Arctic sea ice extent for the month of July was a record low in the observational record. However, the melting did slow in late July and early August. This deceleration in the melt was probably enough to prevent a new all-time record minimum in September this year. There is still a remote possibility of a new record low as the sea ice melt has accelerated this past week with the return of the negative AO. Sea ice extent is near normal near the Canadian and Greenland coasts but well below normal near the Asian and Alaskan coasts (**Figure i**). It will be interesting where sea ice extent remains below normal as sea ice expands in the fall months. Regions of below normal sea ice could favor high latitude blocking in the late fall and winter.

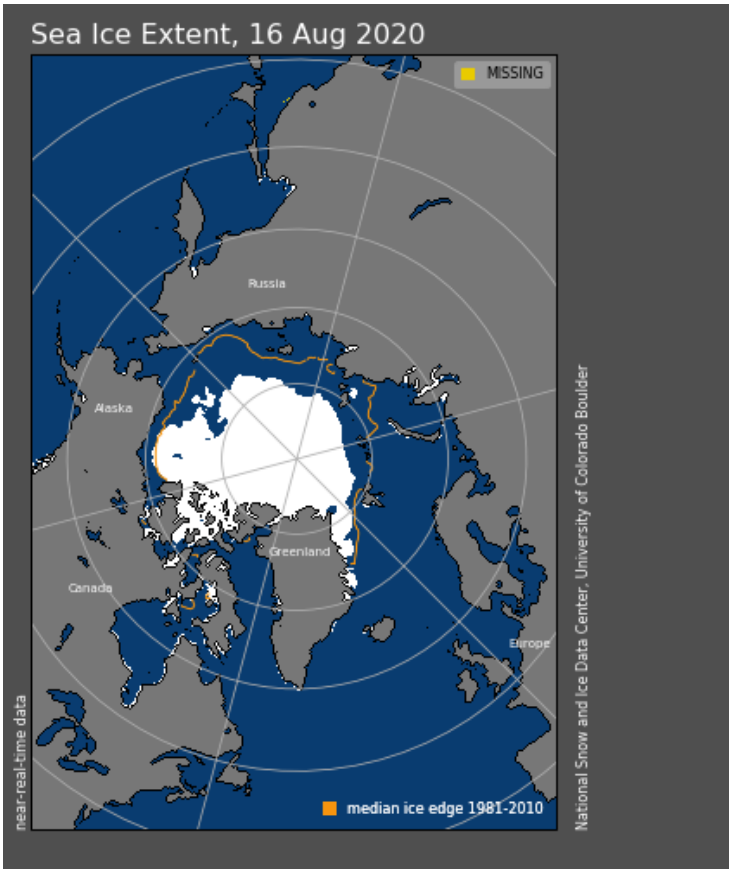

Figure i. a) Observed Arctic sea ice extent on 16 August 2020 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010.

I am excited to introduce a revised pentad GFS surface temperature plots that are not only at higher resolution but more importantly as far as I can tell resolve the inherent warm North America and cold Eurasia bias in the plots. I had help from several colleagues in improving the plots but especially Erik Fanny. The production of the plots is not fully operational yet, and the old plots may appear in tweets in the short term, but I do expect to utilize the new plots in all the blogs going forward.

1-5 day

The AO is currently negative **(Figure 1**) with mostly positive geopotential height anomalies in the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with predicted weak geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to be near neutral this week.

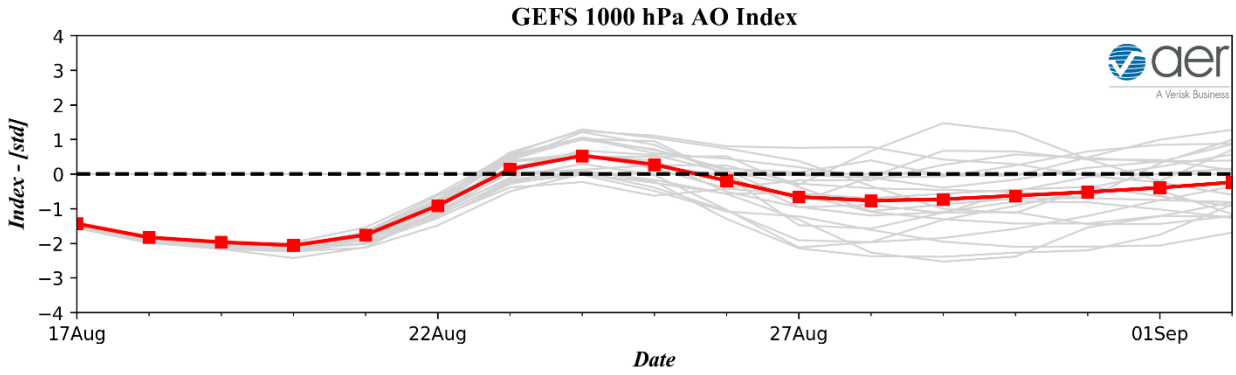

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 17 August 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, though the previously strong ridging/positive geopotential height anomalies across Europe for much of August are predicted to weaken they will persist for one more week (**Figure 2**) resulting in normal to above normal temperatures for much of Europe including the UK (**Figure 3**). Across Asia this week, troughing/negative geopotential height anomalies will be widespread in Western Northeastern Asia with ridging/positive geopotential height anomalies in Central and Southeast Asia (**Figure 2**). This pattern favors normal to below normal temperatures for much of Western Asia and Eastern Siberia with normal to above normal temperatures Central and Far East Asia **(Figure 3**).

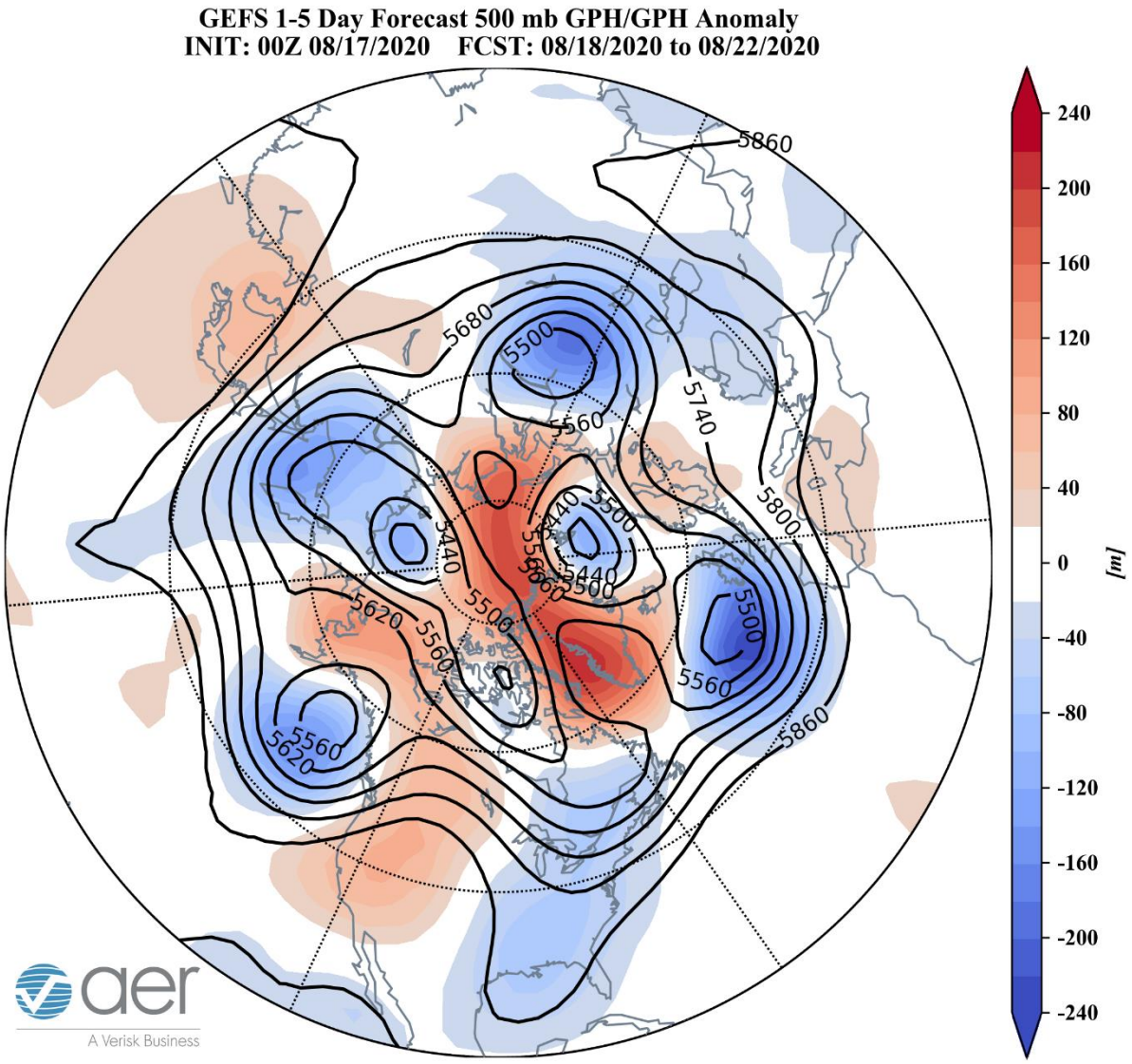

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 – 22 August 2020. The forecasts are from the 00z 17 August 2020 GFS ensemble.

This week, troughing/negative geopotential height anomalies is predicted to stretch from the Canadian Archipelagos through Eastern Canada, the Eastern US right into the Gulf of Mexico while ridging/positive geopotential height anomalies stretch from Alaska through Western Canada and the Western US **(Figure 2).** This pattern is predicted to bring normal to above normal temperatures across Alaska, Western Canada and the Western US with normal to below normal temperatures for much of Eastern Canada and the Eastern US with the exception of Florida where southwest winds will keep temperatures above normal **(Figure 3).**

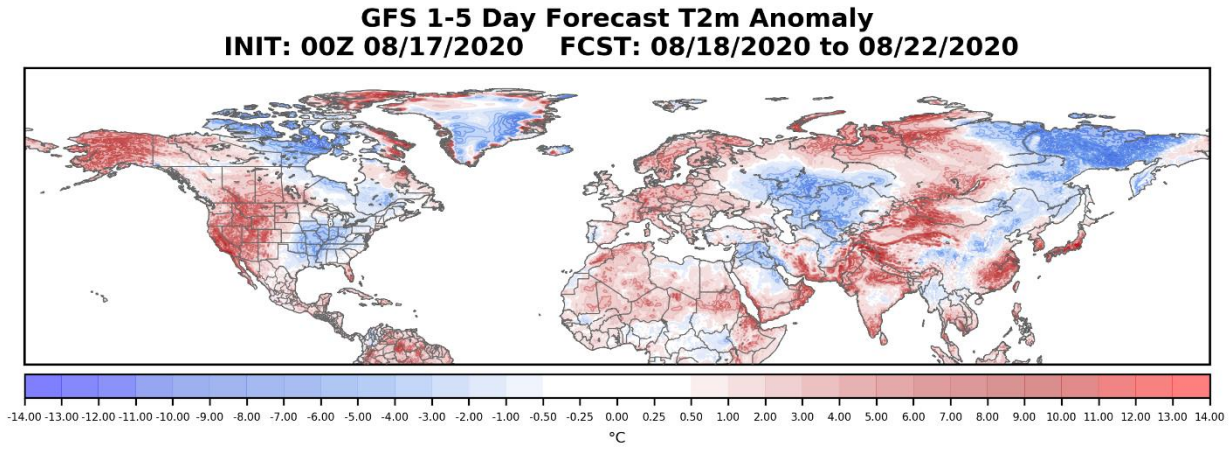

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 18 – 22 August 2020. The forecast is from the 00Z 17 August 2020 GFS ensemble.

Below normal precipitation is predicted for much of Europe and Asia with the exceptions of above normal precipitation in Portugal, western Spain, the UK and parts of South and East Asia (**Figure 4**). Below normal precipitation is predicted for much of North America with above normal precipitation for the West Coast of Canada, the Pacific Northwest and the Canadian Maritimes (**Figure 4**).

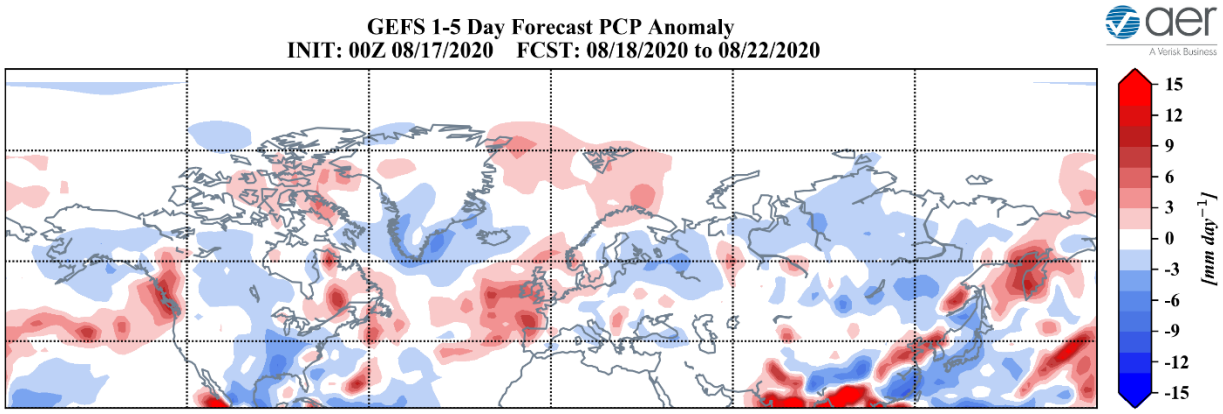

Figure 4. Forecasted precipitation anomalies (mm/day; shading) from 18 – 22 August 2020. The forecast is from the 00Z 17 August 2020 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain neutral to weakly negative **(Figure 1**) as positive geopotential height anomalies dominate the Arctic except for negative geopotential

height anomalies centered on Svalbard and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with weak positive geopotential height anomalies predicted across Greenland (**Figure 5**), the NAO is predicted to remain near neutral to weakly negative as well.

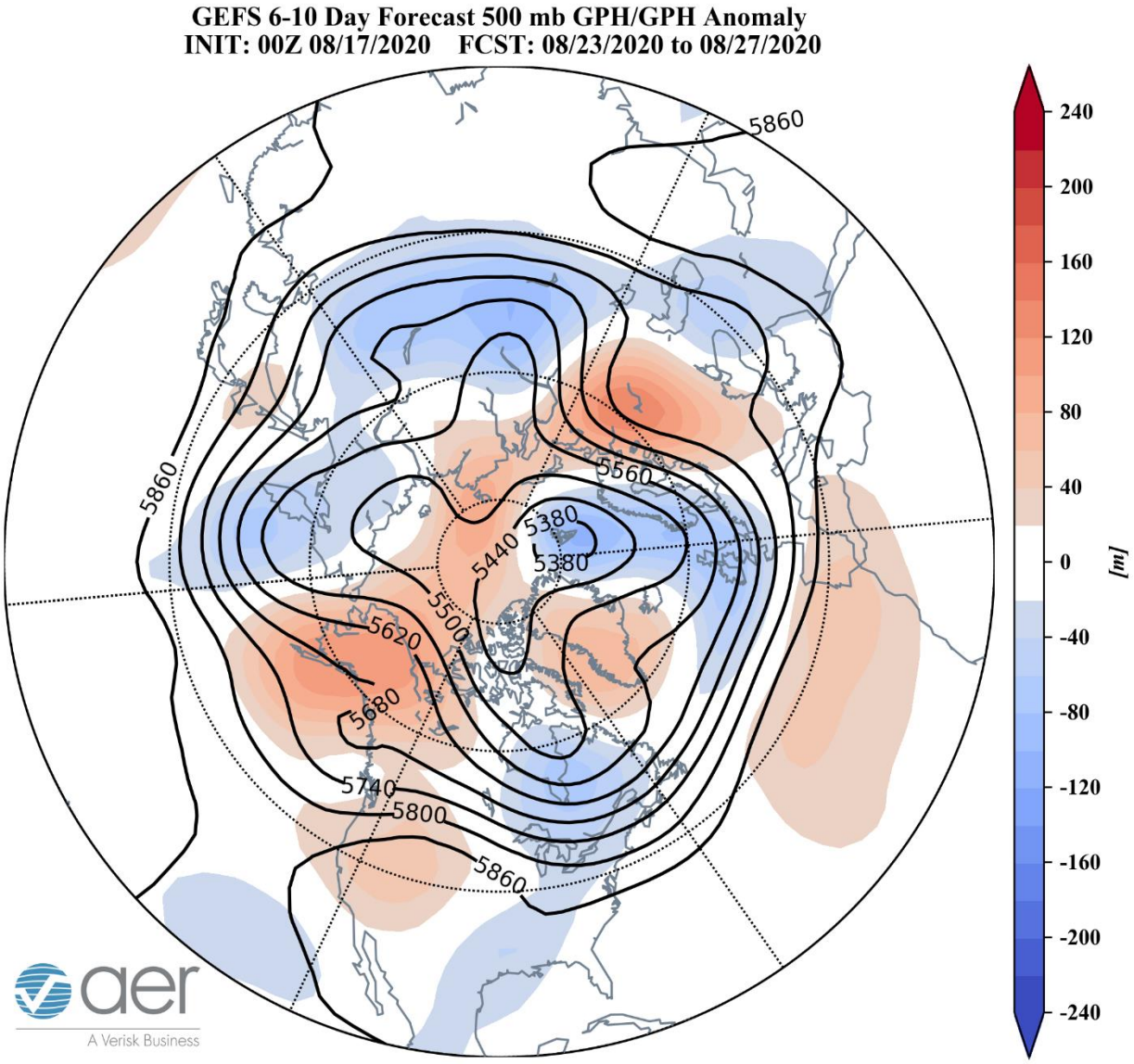

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 23 – 27 August 2020. The forecasts are from the 00z 17 August 2020 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to stretch from Svalbard south across Scandinavia and Western Europe forcing ridging/positive geopotential height anomalies in Eastern Europe (**Figures 5).** This pattern favors normal to below normal across Scandinavia and Northwestern Europe including the UK

with normal to above normal temperatures in Southern and Eastern Europe (**Figure 6**). Ridging/positive geopotential height anomalies across Western and Northern Asia will help support troughing/negative geopotential height anomalies in Central Asia and Eastern Siberia with more ridging in Far East Asia this period (**Figure 5**). This is predicted to yield widespread normal to above normal temperatures in Western, Northern and Eastern Asia **with** normal to below temperatures In Central Asia and Eastern Siberia **(Figure 6**).

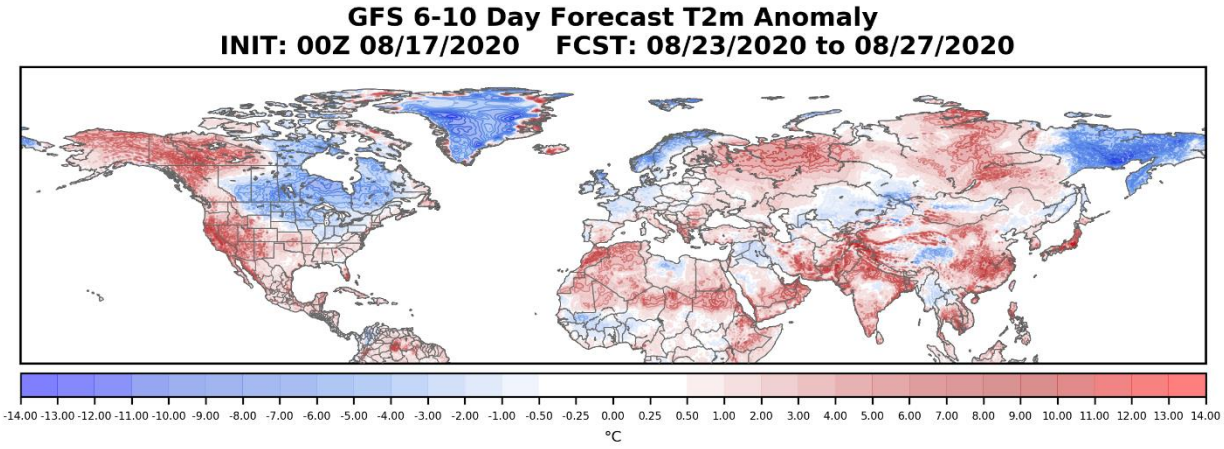

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 23 – 27 August 2020. The forecasts are from the 00Z 17 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to dominate western North America helping to anchor troughing/negative geopotential height anomalies in Eastern Canada and the Eastern US this period (**Figure 5**). This pattern is predicted to bring widespread normal to above normal temperatures across Alaska, Western Canada and the Western and Southern US with normal to below normal temperatures for Eastern Canada and the Northeastern US **(Figure 6).**

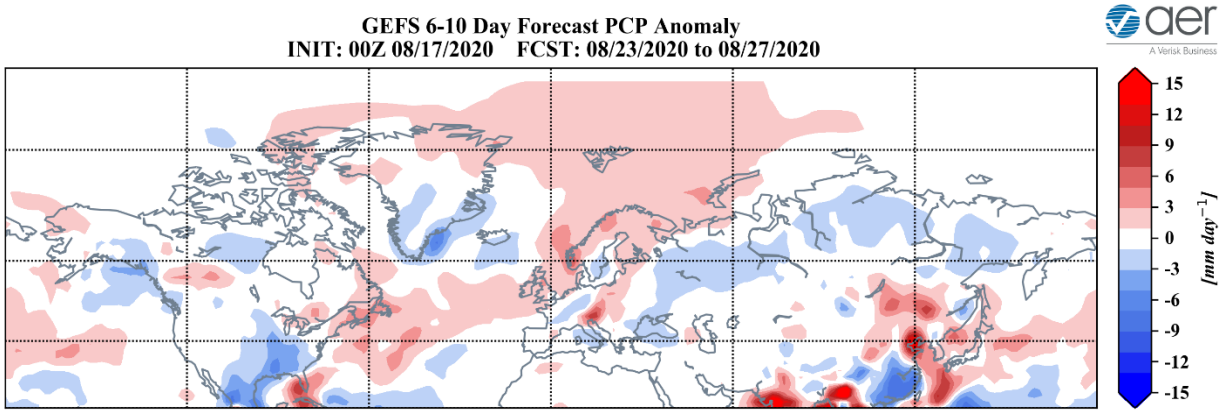

Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 23 – 27 August 2020. The forecasts are from the 00Z 17 August 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia with the exceptions of above normal precipitation across Northern Europe, the Alps and parts of Southern and Eastern Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America with above normal precipitation predicted for Florida (possibly related to tropical activity) and the Canadian Maritimes (**Figure 7**).

11-15 day

With mostly positive but weak positive geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO is predicted to remain weakly negative this period (**Figure 1**). With weak positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to be neutral to weakly negative as well.

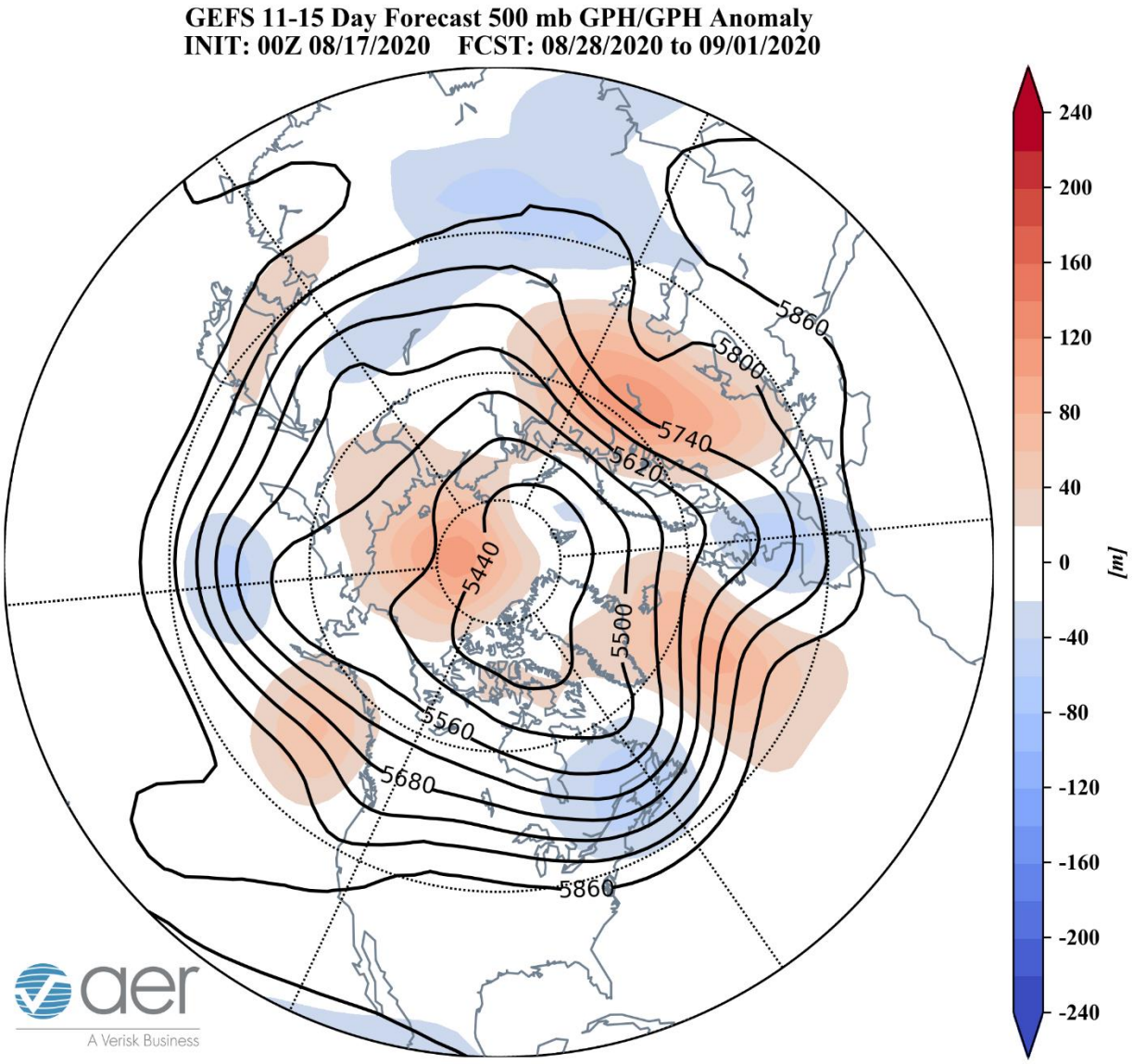

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 28 August – 1 September 2020. The forecasts are from the 00z 17 August 2020 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to settle in across Western Europe with persistent ridging/positive geopotential height anomalies across Eastern Europe this period (**Figures 8**). The forecast is for normal to below normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe this period (**Figures 9**). For Asia, the general predicted pattern is for ridging/positive geopotential height anomalies in Western Asia forcing downstream troughing/negative geopotential height anomalies in Central Asia with more ridging/positive geopotential height anomalies in Far East Asia this period

(**Figure 8**). This pattern favors widespread normal to above normal temperatures across Western and Far East Asia with normal to below normal temperatures across Central Asia (**Figure 9**).

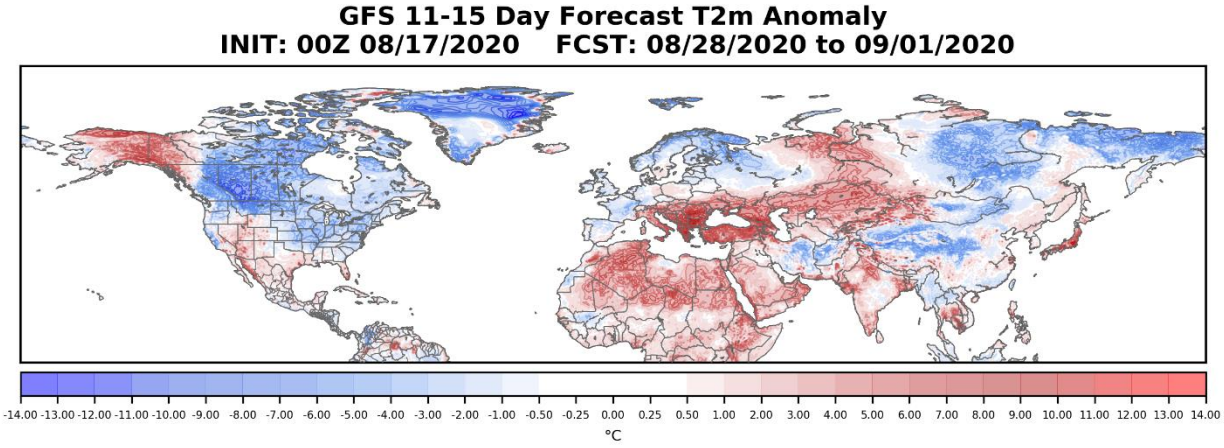

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 28 August – 1 September 2020. The forecasts are from the 00z 17 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to slide a bit west across Alaska and the Gulf of Alaska forcing broad troughing/negative geopotential height anomalies across much of North America (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska and much of the Western US with normal to below normal temperatures for much of Canada and Eastern US (**Figure 9**).

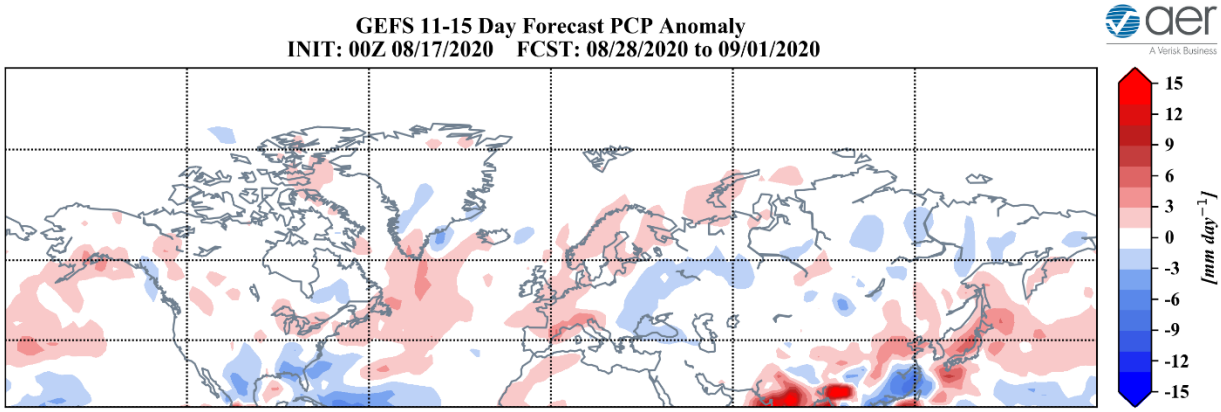

Figure 10. Forecasted precipitation anomalies (mm/day; shading) from 28 August – 1 September2020. The forecasts are from the 00z 17 August 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia except for normal to above normal precipitation for Western Europe and parts of Southern and Far

East Asia (**Figure 10**). Normal to below normal precipitation is predicted for much of North America except for above normal precipitation for Southern Alaska, Western Canada and the Great Lakes (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to above normal PCHs in both the troposphere and the lower stratosphere with normal to below normal PCHs in the mid-stratosphere (**Figure 11**). However, PCHs in the lower stratosphere are predicted to reverse to normal to below normal while PCHs and then descend into the upper troposphere by late August (**Figure 11**). The GFS forecasts of a reversal to cold stratospheric PCHs have been overdone much of the spring and summer and I wouldn't consider the forecast reliable. I am also skeptical of the reverse to cold PCHs in the troposphere.

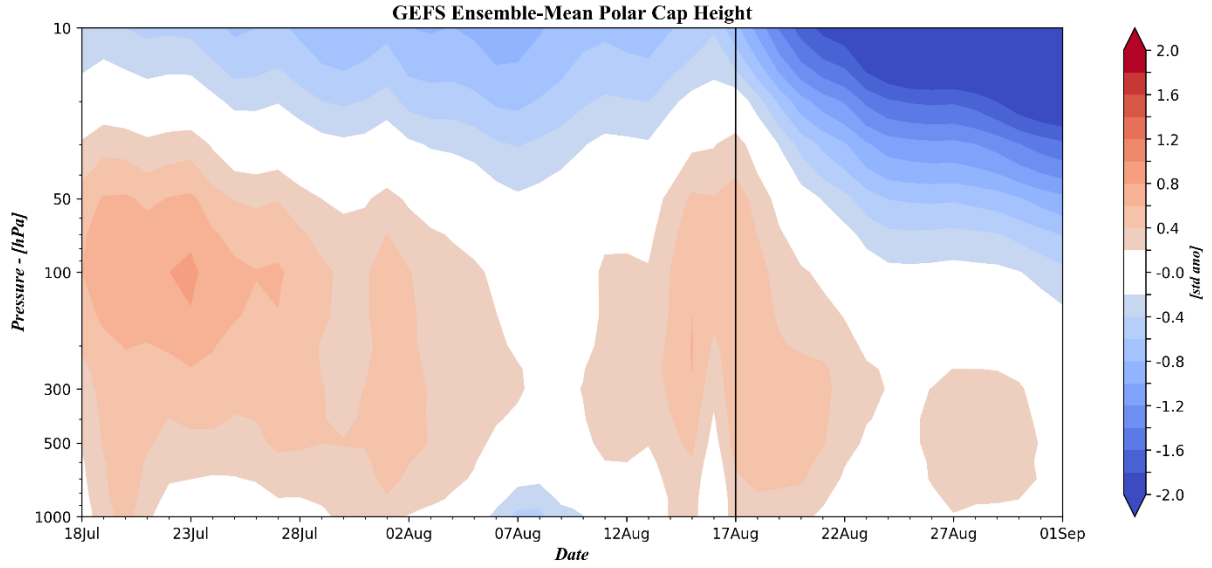

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 17 August 2020 GFS ensemble.

The current above normal PCHs in the troposphere are consistent with the predicted negative AO this week (**Figure 1**). I do believe that the overall below normal sea ice and Arctic warming favor mostly normal to above normal PCHs in the troposphere throughout the summer months, with typical synoptic timescale variability and therefore expect the warm/positive PCHs to continue into early September.

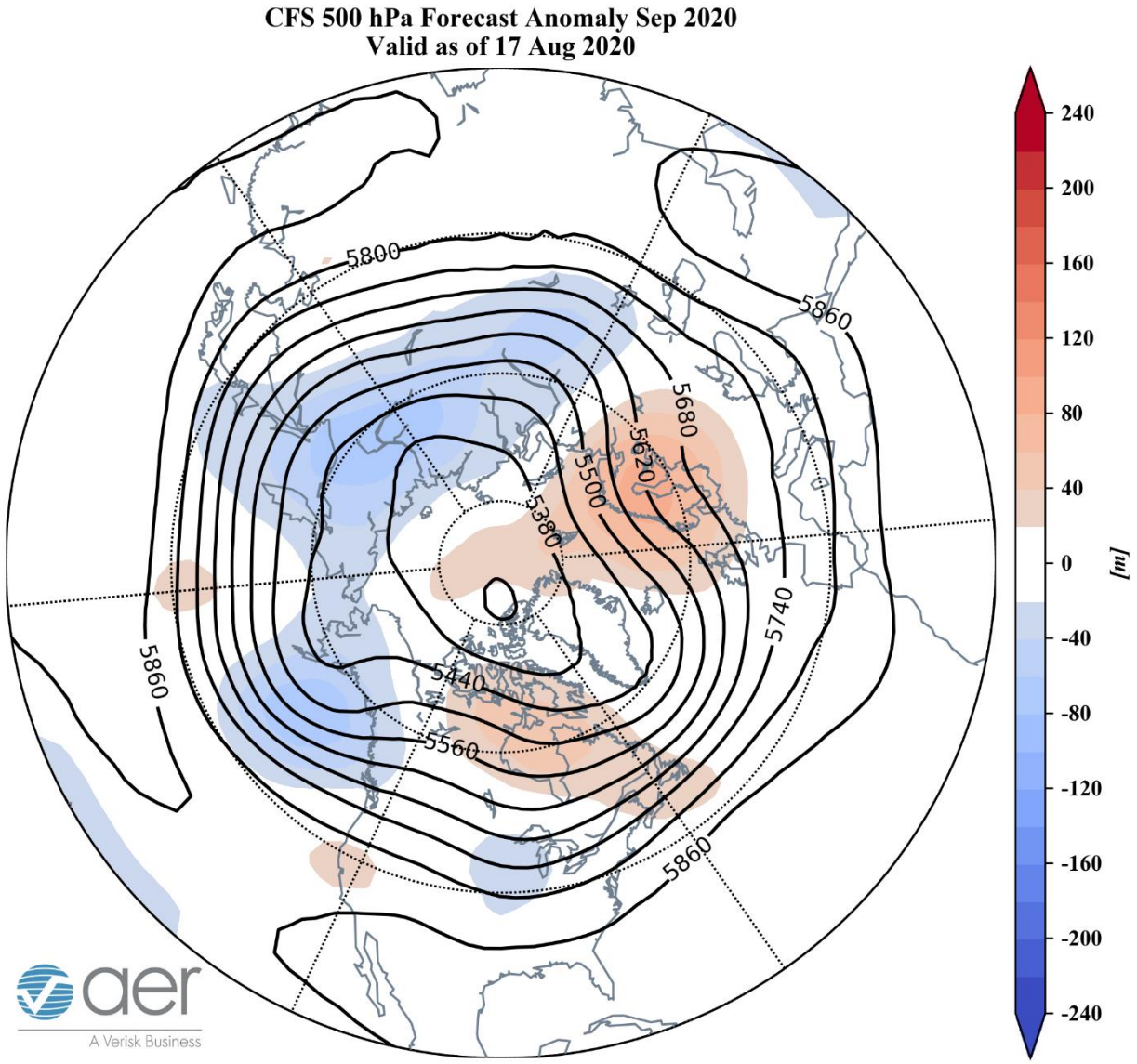

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2020. The forecasts are from the 00Z 17 August 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for September from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered across Scandinavia, the Dateline, the Western US (albeit very weak) and northeastern Canada with troughing in the Mediterranean, Northern Asia, the Gulf of Alaska and eastern North America (**Figure 12).** This pattern favors relatively warm temperatures for Scandinavia, Central Asia and western North America with seasonable to relatively cool temperatures for Southern Europe, the Middle East, Siberia, Southeastern Canada and the Northeastern US(**Figure 13**).

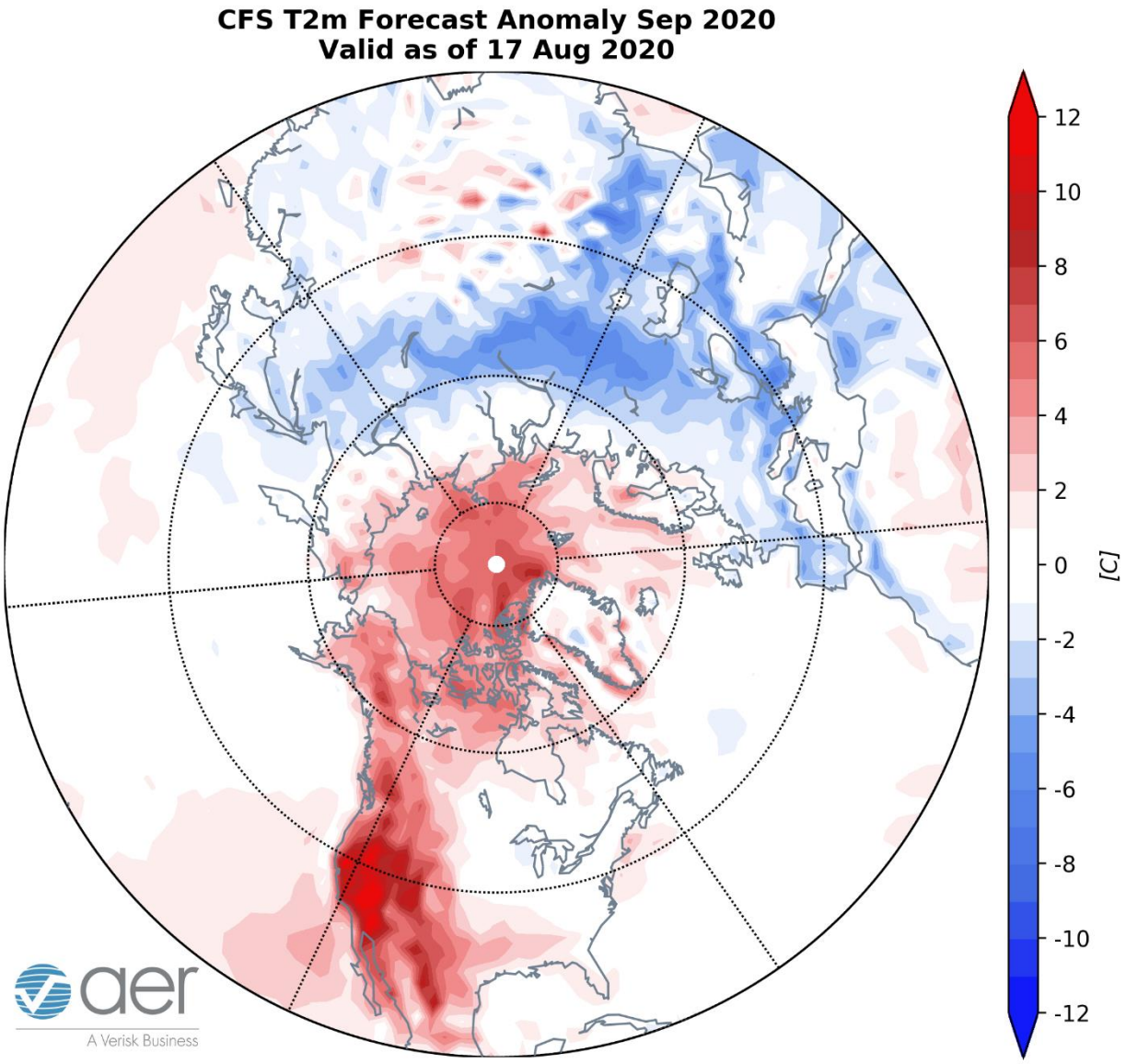

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for September 2020. The forecasts are from the 00Z 17 August 2020 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies continue to cool slowly but neutral El Niño/Southern Oscillation (ENSO) conditions still exist (**Figure 14**) though a La Niña is expected by this fall. Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska, the western North Pacific and

offshore of eastern North America though below normal SSTs exist regionally especially in the Southern Hemisphere and south of Iceland. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

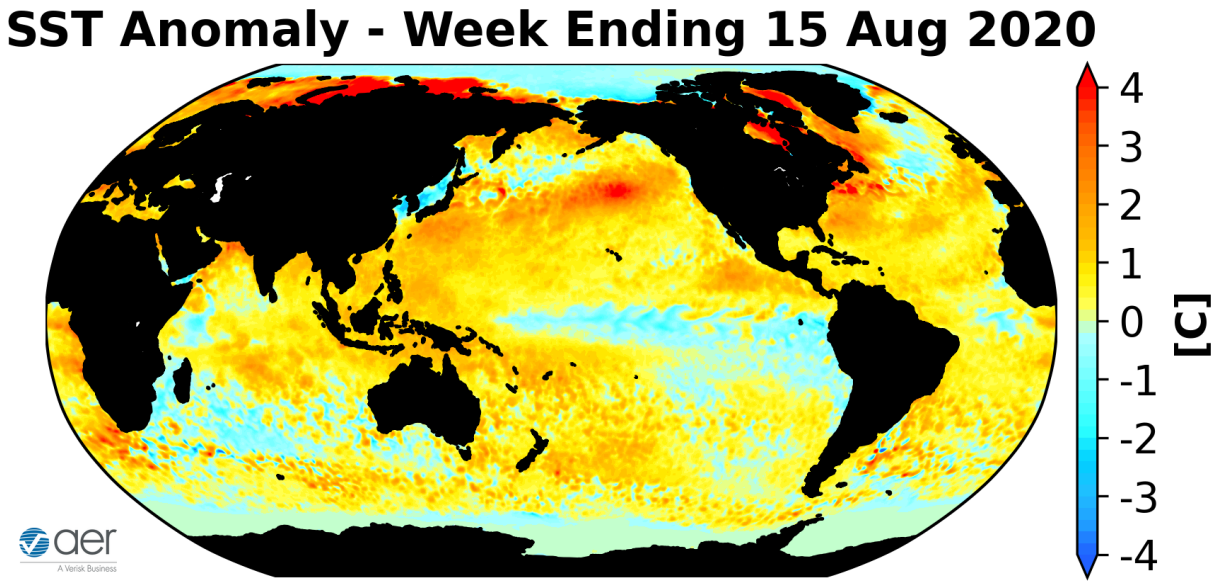

Figure 14. The latest weekly-mean global SST anomalies (ending 1 August 2020). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase eight (**Figure 15**). The forecasts are for the MJO to then enter phase one. MJO phases eight and one mostly favor troughing in the Gulf of Alaska and ridging across much of North America. The MJO could be contributing to the very short-term pattern across North America but otherwise does not seem to be contributing to the pattern for the next two weeks.

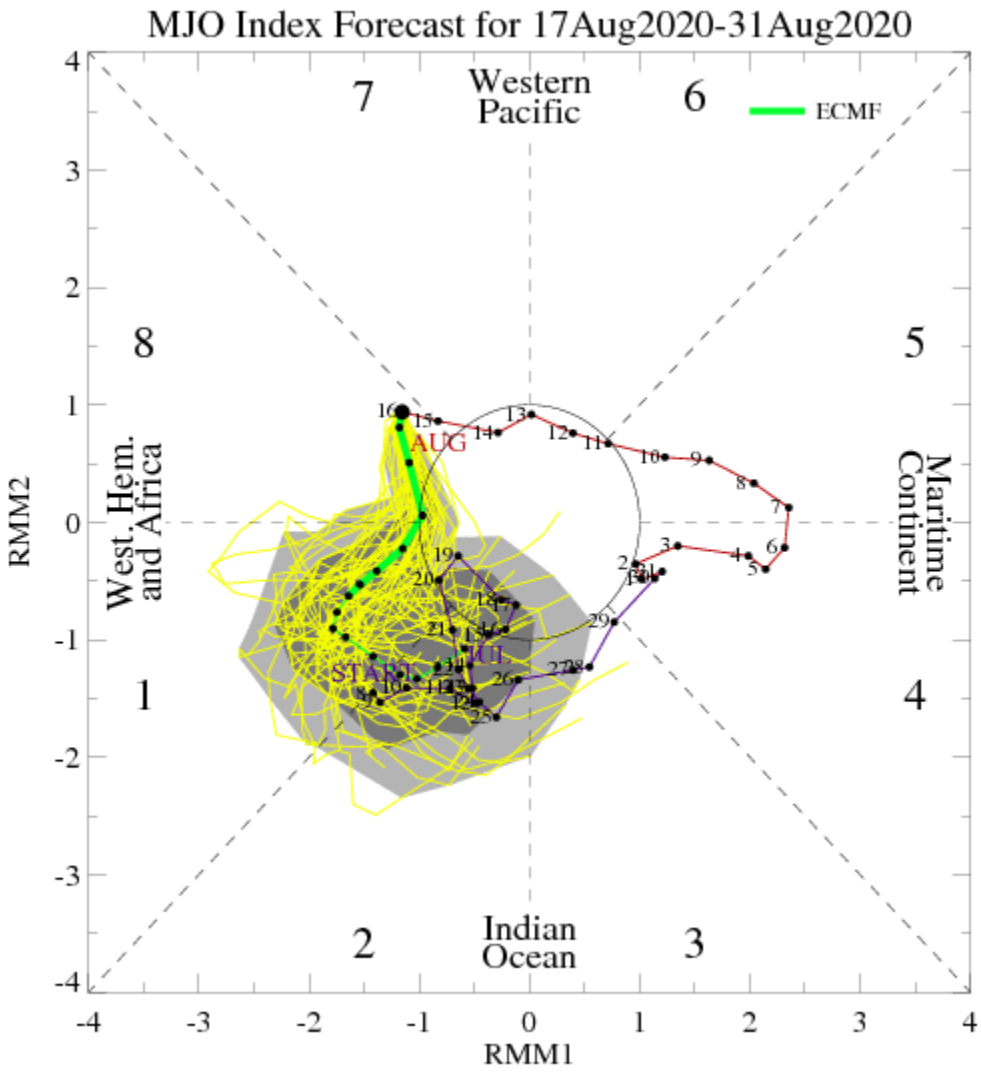

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 17 August 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source: http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html